Letters to the Editor

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Gravitational red shift of spectral lines

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Gravitational red shift is an established experimentally observed phenomenon. The red shift can be derived from potential energy/mass relationship in the gravitational field. Attempts have been made to derive the red shift from metric properties of space as by McVittie (1965). He defines frequency in an invariant fashion (inverse of proper time) and ignores the drop in speed of light near a gravitating mass. A derivation has been given by Stoeckli (1971) from consideration of metric transformation as well as quantum mechanics Frequency is not invariant, but the derivation deals only with observations in free space for the two cases of emission either in free space (S_2) or in the vicinity (S_1) of the gravitating mass m of radius R. His derivation is silent about the effect if any on emission at S_1 if observed at S_1. Below is given a derivation from classical Bohr theory and the straightforward metric transformation

Bohr theory suggests that the frequency emitted by an atom on the surface of gravitating mass would be for observations in system S_1 .

$$\nu_m \propto 1/\epsilon_m^2 \qquad \ldots \quad (1)$$

where ϵ_m is the dielectric constant The effective speed of light at S_1 would be

$$C_m = e^{-(\alpha+\beta)}c, \qquad \ldots \quad (2)$$

as deduce in Yilmaz (1965), where α, β are the constants in the Schwartzchild equation Neglecting higher powers of m/R, they are given by

$$e^{\alpha} = e^{\beta} = (1+m/R) \qquad \ldots \quad (3)$$

Assuming symmetry in dielectric constant ϵ and the magnetic permittivity μ and using (2) and the relation $C_m = 1/(\epsilon_m \ \mu_m)^{\frac{1}{2}}$, we get

$$\epsilon_m = (1+2m/R)\epsilon_0, \qquad \ldots \quad (4)$$

where ϵ_0 is the value for free space S_2. Using the relationship between frequency and wavelength and equation (1) and (4), we get the wave length λ_m when observed at S_1 to be

$$\lambda_m = (1+2m/R)\lambda_0 \qquad \ldots \quad (5)$$

where λ_0 is the wavelength observed in free space when the emission is also in free space. Now, we can use the metric transformation for coordinate length derivable from equations (6) of Stoeckli's (1971) paper

$$dr = (1-m/R_0)dr_m \quad \ldots \quad (6)$$

When dr is for tangential space in S_2 and dr_m is for S_1. Applying (6) to lengths

$$\lambda_{obs} = dr \text{ and } \lambda_m = dr_m,$$

we get

$$\lambda_{obs} = (1+m/R_0)\lambda_0. \quad \ldots \quad (7)$$

Equation (7) gives the gravitational red shift as experimentally observed. The equation (5) gives the much larger red shift that is effective for the radiation when dealt with in the system S_1 In this derivation mass of electron is kept constant in the systems S_1 or S_2 In case due to intense gravity there is change in mass of electron the red shift will be anomalous

References

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Penetration effects in the 134 keV transition in ^{187}Re.

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Nuclear penetration effects are usually found to affect the internal conversion process of the retarded magnetic dipole transitions. The penetration factor λ, is a measure of the degree of overlap of the electron and nuclear wave functions between the initial bound state and final free state of the electron The nuclear parameter λ is sizeable if the gamma ray transition matrix element is reduced This parameter is defined as the ratio of the electron penetration matrix element M_e and gamma ray emission matrix element M_γ *i.e.* $\lambda = M_e/M_\gamma$. A number of transitions have been found to have λ specifically different from unity (normal conversion). These gamma ray transitions are invariably of hindered type.